Australian Islamic College 2018

ATAR Chemistry Units 3 and 4

Task 6 (Weighting: 3%)

REDOX and Electrochemistry Test

Test Time: 45 minutes

Please do not turn this page until instructed to do so.

First Name	Surname
Answers	

Teacher

Mark / 48	Percentage

Equipment allowed: Pens, pencils, erasers, whiteout, rulers and non-programmable calculators permitted by the Schools Curriculum and Standards Authority.

Special conditions: 2 marks will be deducted for each of these: Failing to write your full name on this test paper; failing to use the multiple choice answer sheet correctly.

Multiple choice questions must be answered on the multiple choice answer sheet provided. Answers placed elsewhere will not be marked.

Teacher help: Your teacher can only help you during your test in one situation.
If you believe there is a mistake in a question show your teacher and your teacher will tell you whether or not there is a mistake in the question and if appropriate, how to fix that mistake.

Short answer questions must be answered in this booklet, in the spaces provided.

Total marks: 48

PART 1: Multiple Choice

12 marks

Write your answers on the multiple choice answer sheet at the back of this paper.

1. Which of the following contains a **bolded atom** in a different oxidation state to the rest?

   (a) $KAsO_4$

   (b) HNO_3

   (c) $H_4Bi_2O_7$

   (d) HPO_4^{2-}

2. Concentrated sulfuric acid (H_2SO_4) is able to act as an oxidising agent. Which one of the following equations illustrates this ability?

   (a) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

   (b) $Zn + 2H_2SO_4 \rightarrow ZnSO_4 + 2H_2O + SO_2$

   (c) $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$

   (d) $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

3. Which one of the following is/are redox reactions?

   i. $Zn_{(s)} + 2H^+_{(aq)} + 2NO_3^-{}_{(aq)} \rightarrow Zn(NO_3)_{2(aq)} + 2NO_{2(g)} + 2H_2O_{(l)}$

   ii. $Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4(s)}$

   iii. $CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$

   iv. $2Na_{(s)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + H_{2(g)}$

   v. $Fe_{(s)} + Cu^{2+}_{(aq)} \rightarrow Cu_{(s)} + Fe^{2+}_{(aq)}$

   (a) i and ii only

   (b) ii and v only

   (c) ii, iii and iv

   (d) i, iv and v

4. Which of the following would oxidise bromide ion (Br^-) but not chloride ions (Cl^-) from a 1.0 mol L^{-1} solution mixture containing both $NaBr_{(aq)}$ and $NaCl_{(aq)}$?

(a) A 1.0 molL^{-1} solution of acidified $K_2Cr_2O_7$

(b) A 1.0 molL^{-1} solution of acidified H_2O_2

(c) A 1.0 molL^{-1} solution of $Mn(NO_3)_2$

(d) A 1.0 molL^{-1} solution of KF

5. Which of the following reactions is **unlikely** to occur under standard conditions of 25 °C and 1.0 mol L^{-1} solutions?

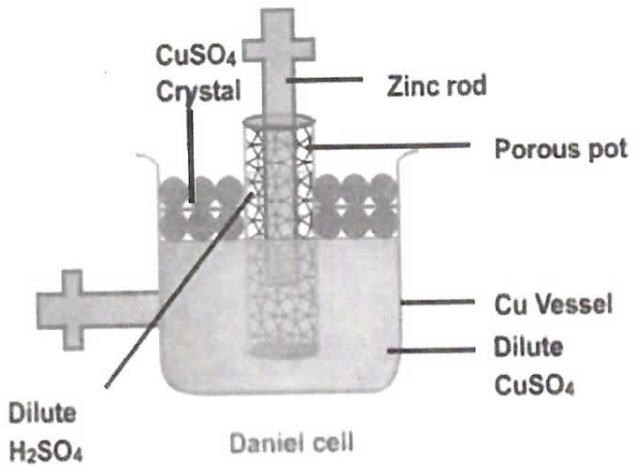
(a) $H_2S_{(aq)} + Cl_{2(aq)} \rightarrow S_{(s)} + 2Cl^-_{(aq)} + 2H^+_{(aq)}$

(b) $H_2O_{2(aq)} + Cl_{2(aq)} \rightarrow O_{2(g)} + 2H^+_{(aq)} + 2Cl^-_{(aq)}$

(c) $2Cl^-_{(aq)} + Cu^{2+}_{(aq)} \rightarrow Cu_{(s)} + Cl_{2(g)}$

(d) $2Fe^{3+}_{(aq)} + Fe_{(s)} \rightarrow 3Fe^{2+}_{(aq)}$

6. One classical example of an electrochemical cell is the Daniel cell



The positive electrode in the Daniel cell above is the

(a) zinc rod

(b) copper vessel

(c) porous pot

(d) $CuSO_4$ crystal

7. The half equations and standard reduction potentials for the ions $Cu^{+}_{(aq)}$ and $Cu^{2+}_{(aq)}$ are as follows:

$Cu^{+}_{(aq)} + è \rightarrow Cu_{(s)}$ $\quad E^{o} = +0.52$ V

$Cu^{2+}_{(aq)} + 2è \rightarrow Cu^{+}_{(aq)}$ $\quad E^{o} = +0.15$ V

The standard potential, in Volts, for the disproportionation reaction: $\mathbf{2Cu^{+}_{(aq)} \rightarrow Cu^{2+}_{(aq)} + Cu_{(s)}}$ is

(a) - 0.67 V

(b) - 0.37 V

(c) + 0.37 V

(d) + 0.67 V

8. In an experiment performed at standard conditions, a student made the following observatory notes:

i. clean metal A did not react with 1.0 mol/L solution containing B^{2+} ions

ii. clean metal B dissolved in 1.0 mol/L solution containing C^{2+} ions and crystals of C appeared

iii. clean metal C did not react with 1.0 mol/L solution containing A^{2+} ions

According to the notes, the order of strength as an oxidising agent is

(a) C^{2+} ions > A^{2+} ions > B^{2+} ions

(b) C^{2+} ions > B^{2+} ions > A^{2+} ions

(c) A^{2+} ions > B^{2+} ions > C^{2+} ions

(d) B^{2+} ions > A^{2+} ions > C^{2+} ions

9. An electrochemical cell made from the following reaction has a voltage reading of 1.03 V

$$Cl_2 + 2V^{3+} + 2H_2O \rightarrow 2VO^{2+} + 4H^{+} + 2Cl^{-}$$

What is the standard reduction potential for the reaction where VO^{2+} is converted to V^{3+}?

(a) - 3.05 V

(b) - 0.33V

(c) + 0.33 V

(d) + 3.05V

10. Consider a zinc/copper electrochemical cell containing copper electrode in 1.0 mol L^{-1} copper(II) sulfate solution and zinc metal in 1.0 mol L^{-1} $Zn(NO_3)_2$ solution.

Which of the following saturated solutions at 25 °C and atmospheric pressure can be used as a salt bridge?

(i) $NaNO_3$ (ii) KBr (iii) Na_2CO_3

(a) i only

(b) i and ii only

(c) i and iii only

(d) all three solutions are suitable

11. A group of students is designing an electrochemical cell consisting of two half cells joined by a salt bridge. Each of the half-cells consists of a metal rod placed in a 1.0 mol L^{-1} solution of its nitrate. Which of the following pairs of half-cells will produce the highest voltage (EMF) under standard conditions?

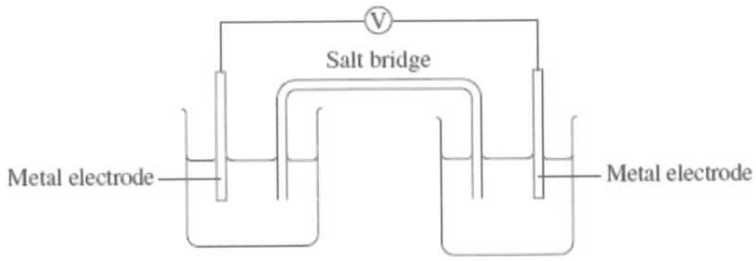
(a) Aluminium in aluminium nitrate solution and iron in iron(II) nitrate solution.

(b) Copper in copper(II) nitrate solution and zinc in zinc nitrate solution.

(c) Lead in lead(II) nitrate solution and manganese in manganese(II) nitrate solution.

(d) Silver in silver nitrate solution and magnesium in magnesium nitrate solution.

12. Four metals **Pb**, *x*, *y* and *z*, were connected in pairs and the voltage was recorded.



The results obtained are set out in the table below. What is the order of increasing ease of oxidation of the metals?

Negative terminal	***Positive terminal***	***Voltage (V)***
Pb	*x*	0.35
y	**Pb**	1.10
z	**Pb**	2.60

(a) *z*, *y*, Pb, *x*

(b) Pb, *x*, *y*, *z*

(c) *x*, *y*, Pb, *z*

(d) *x*, Pb, *y*, *z*

PART 2: SHORT ANSWER **36 marks**

Answer each of the following questions in the space provided.

Question 1 **4 marks**

Write balanced equations for the reactions that occur in the following experiments. Use **ionic** equations where appropriate. In each case describe observations such as colour changes, precipitate formation (give the colour), or gas evolution (give colour or describe as colourless) resulting from the chemical reactions. **Include** state subscripts.

(a) A strip of chromium metal is placed in a 1.0 $molL^{-1}$ solution of cobalt (II) nitrate solution.

Equation: $2Cr_{(s)} + 3Co^{2+}_{(aq)} \rightarrow 2Cr^{3+}_{(aq)} + 3Co_{(s)}$ (1)

Observation: A silvery metal is added to a pink solution. The silvery metal disappears. The solution turns deep green. A silvery metal appears. Any 2, ½ each. Marks off for wrong observations.

[2 marks]

(b) A small quantity of bromine water ($Br_{2(aq)}$) is added to 10.0 mL of 1.0 mol L^{-1} sodium iodide solution.

Equation: $Br_{2(aq)} + 2I^-_{(aq)} \rightarrow I_{2(aq)} + 2Br^-_{(aq)}$ (1)

Observation: An orange liquid is added to a colourless liquid. The liquid turns brown.

Any 2, ½ each. Marks off for wrong observations.

[2 marks]

Equations - no half marks.

Question 2 **3 marks**

According to Wikipedia, hypoiodous acid (**HIO**) is highly likely to be the active ingredient responsible for disinfection by iodine solutions used in the medical profession. Examples of such solutions include betadine or povidone.

Hypoiodous acid is quite unstable and it disproportionates to form iodic acid (HIO_3) and iodine solutions.

Write half equations to show the oxidation and reduction of hypoiodous acid and the overall redox equation for the disproportionation of hypoiodous acid.

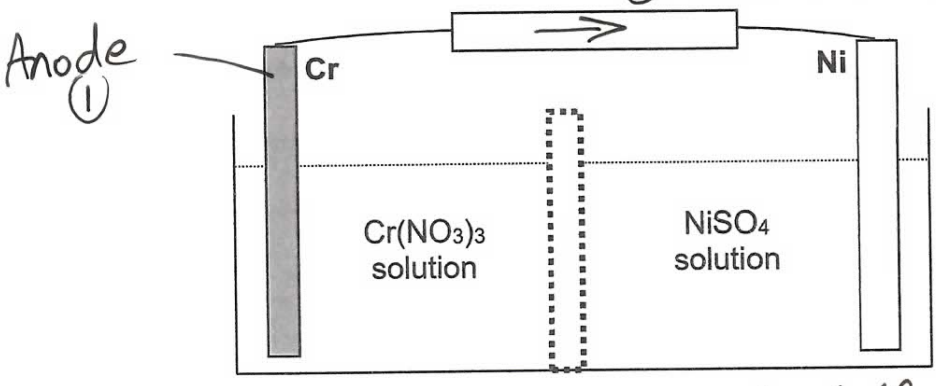
No half marks

Oxidation half equation: $HIO_{(aq)} + 2H_2O_{(\ell)} \rightarrow HIO_{3\,(aq)} + 4H^+_{(aq)} + 4e^-$ ①
Reduction half equation: $2HIO_{(aq)} + 2H^+_{(aq)} + 2e^- \rightarrow I_{2\,(aq)} + 2H_2O_{(\ell)}$ ①
Overall redox equation: $5HIO_{(aq)} \rightarrow HIO_{3\,(aq)} + 2I_{2\,(aq)} + 2H_2O_{(\ell)}$ ①

Question 3 **14 marks**

The following diagram represents an electrochemical cell based on chromium and nickel electrodes in 1.0 mol L^{-1} electrolyte solutions. A porous barrier separates the two half cells but allows ions to migrate between them. The cell operates under standard conditions.

① Arrow must be inside box



No half marks

(a) Write the anode, cathode and overall redox equation for the cell above. [3 marks]

Anode: $Cr_{(s)} \rightarrow Cr^{3+}_{(aq)} + 3e^-$ ①

Cathode: $Ni^{2+}_{(aq)} + 2e^- \rightarrow Ni_{(s)}$ ①

Overall: $2Cr_{(s)} + 3Ni^{2+}_{(aq)} \rightarrow 2Cr^{3+}_{(aq)} + 3Ni_{(s)}$ ①

(b) On the diagram, label the electrode that is the anode. [1 mark]

(c) Draw an arrow in the box provided to show the direction of the electron flow in the wire. [1 mark]

(d) What is the maximum theoretical EMF (voltage) that can be generated? (Assume 1.0 mol L^{-1} concentrations and standard conditions) [1 mark]

+0.50 V ① (½ off if unit wrong/missing)

(e) Which anion (negative ions) will migrate through the porous barrier? [1 mark]

Sulfate / SO_4^{2-} ①

(f) State two (2) changes that will be observed. [2 marks]

i. Anode / Cr electrode becomes smaller / thinner / loses mass.

ii. Cathode / Ni electrode become thicker / larger / gains mass.

Any 2; 1 each.

Cr^{3+} sol^n becomes darker green. Ni^{2+} sol^n becomes lighter green.

(g) What will be observed if the porous barrier is removed and the solutions become mixed? [2 marks]

Current stops. ①

Cr electrode stops becoming thinner. ①

Ni electrode stops becoming thicker ①

Any 2; ① each.

(h) The standard reduction potential for nickel metal is (- 0.24 V). Explain the role of the hydrogen half-cell in determining this value. Comment on the significance of the negative value. You may use diagrams to aid your explanation. [3 marks]

Hydrogen half-cell is assigned an E° of 0.00V / is the reference cell. ①

The nickel half-cell E° is relative to the hydrogen half-cell. ①

A negative value for E° means that Ni is a stronger reducing agent than hydrogen. ①

Appropriate diagram, labelled, including H_2, H^+ and Pt. ①

Question 4 **3 marks**

Rusting occurs when iron metal is exposed to air. The **unbalanced chemical** equation for the rusting process is below:

$$2\,Fe_{(s)} + O_{2(g)} + 2\,H_2O_{(l)} \rightarrow 2\,Fe^{2+}_{(aq)} + 4\,OH^-_{(aq)}$$

2; 1 off per mistake.

(a) Balance the chemical equation above. [2 marks]

(b) In many situations, the first visible sign of iron corrosion is the formation of a light green powder on the affected metal. Write a suitable **ionic** chemical equation to explain this observation.

$Fe^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Fe(OH)_{2(s)}$ [1 mark]

or

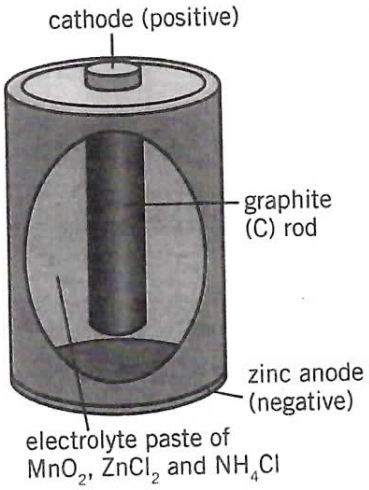
$2Fe_{(s)} + O_{2(g)} + 2H_2O_{(l)} \rightarrow 2Fe(OH)_{2(s)}$

or

$Fe_{(s)} \rightarrow Fe^{2+}_{(s)} + 2e^-$

Question 5 **5 marks**

Below is a diagram of the common dry cell:



Given the cathode reaction is:

$$2MnO_{2(s)} + 2H^+_{(aq)} + 2e^- \rightarrow Mn_2O_{3(s)} + H_2O_{(l)}$$

(a) Determine the oxidation state of the Mn before and after the reaction:

Before: +4 (1) After: +3 (1) [2 marks]

(b) State the oxidant in the cell: MnO_2 (1) [1 mark]

(c) Given that the anode reaction is the oxidation of zinc, write the equation for the overall reaction of the cell:

$2MnO_{2(s)} + 2H^+_{(aq)} + Zn_{(s)} \rightarrow Mn_2O_{3(s)} + H_2O_{(l)} + Zn^{2+}_{(aq)}$ [2 marks]

(2); 1 off per mistake

Question 6 **7 marks**

The lead acid battery, or accumulator, is commonly used in motor vehicles and consists of six cells connected in series.
When **discharging**, the electrode reactions are:

ANODE: $Pb_{(s)} + SO_4^{2-}{}_{(aq)} \rightarrow PbSO_{4(s)} + 2e^-$

CATHODE: $PbO_{2(s)} + 4H^+{}_{(aq)} + SO_4^{2-}{}_{(aq)} + 2e^- \rightarrow PbSO_{4(s)} + 2H_2O_{(l)}$

Part	Question	Answer
(a)	During the **recharging** process, what is the i. reducing agent? ii. oxidising agent?	i. $PbSO_4$ (1) ii. $PbSO_4$ (1) [2 marks]
(b)	How would the concentration of the electrolyte change during the **recharging** process?	Circle one of the choices below INCREASE DECREASE UNCHANGED [1 mark]
(c)	How would the pH inside the battery change during: i. recharging? ii. discharging?	Circle one of the choices in parts (i) and (ii) i. INCREASE DECREASE UNCHANGED [1 mark] ii. INCREASE DECREASE UNCHANGED [1 mark]
(d)	State one advantage and one disadvantage of this battery. Explanation is not required.	Advantage: Rechargeable / long life / low cost / reliable / high current. Any 1, (1). [1 mark] Disadvantage: Lead is poisonous, heavy, acid is corrosive, sulfation, must be stored charged, low energy density. Any 1, (1). [1 mark]

MULTIPLE CHOICE ANSWER SHEET

For each question shade the box to indicate your answer.
Use **only** a blue or black **pen** to shade the boxes.

For example, if b is your answer: a ☐ b ■ c ☐ d ☐

If you make a mistake, place a cross through that square then shade your new answer.
Do not erase or use correction fluid.

For example, if b is a mistake and d is your answer: a ☐ b ☒ c ☐ d ■

If you then want to use your first answer b, cross out d and then circle b.

a ☐ b ◉ c ☐ d ☒

Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

1	a ■ b ☐ c ☐ d ☐	6	a ☐ b ■ c ☐ d ☐	11	a ☐ b ☐ c ☐ d ■
2	a ☐ b ■ c ☐ d ☐	7	a ☐ b ☐ c ■ d ☐	12	a ☐ b ☐ c ☐ d ■
3	a ☐ b ☐ c ☐ d ■	8	a ■ b ☐ c ☐ d ☐		
4	a ■ b ☐ c ☐ d ☐	9	a ☐ b ☐ c ■ d ☐		
5	a ☐ b ☐ c ■ d ☐	10	a ☐ b ■ c ☐ d ☐		